

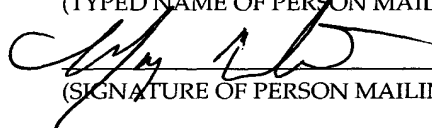
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City Place II  
185 Asylum Street  
Hartford, CT 06103-4102  
Tel. (860) 549-5290

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ATTACHMENT TO A PATENT APPLICATION

DOCKET NO.: 6006-149-1  
ENTITLED: DUCT REINFORCEMENT ROD AND FABRICATION APPARATUS  
INVENTOR(S): John J. Toben and Michael C. Borwig  
INCLUDING: Specification; Claims; Abstract; and 16 sheets of Informal Drawings

## **DUCT REINFORCEMENT ROD AND FABRICATION APPARATUS**

### **CROSS REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims the benefit of U.S. Provisional Application Serial No. 60/412,722, filed on September 23, 2002, herein incorporated by reference in its entirety.

### **FIELD OF THE INVENTION**

[0002] This invention relates in general to a duct reinforcement rod and fabrication apparatus, and deals more particularly with a duct reinforcement rod and fabrication apparatus which increases the structural stability of ductwork while reducing fabrication time and component expense.

### **BACKGROUND OF THE INVENTION**

[0003] Ductwork is utilized to facilitate the heating, ventilation and cooling of various buildings, both residential and commercial. The ductwork typically comprises individual duct sections which are then coupled together to form a continuous, largely airtight duct for conveying a moving mass of air.

[0004] The duct sections are typically made from strong, yet relatively light, material such as sheet metal, or the like. It is an important design characteristic that the duct remain as lightweight as possible in order to minimize the size and weight of fasteners and other structural components required to support the ductwork, as well as maintaining materials and fabrication costs of the ductwork itself at reasonable costs.

[0005] Commonly utilized ductwork often have rectangular, circular or oval cross sections, and are frequently manufactured and supplied in pre-cut lengths or sections with transversely outwardly protruding interconnection flanges, provided at opposite longitudinal ends of the section, to facilitate interconnecting duct sections at a job site and thus form the finished air conveying ducts of desired lengths.

[0006] Whatever the size or shape of the ductwork, the relatively small thickness of the walls of the ductwork, as compared to its cross-sectional dimensions, results in the duct walls being rather flexible. Conventional ductwork may therefore experience large, possibly destructive and oftentimes loud structural deformations if static or dynamic air pressure differentials between the interior and the exterior of the ductwork exceeds a predetermined threshold value. For this reason, mechanical engineering standards, as well as most building codes, require that certain ductwork be reinforced against expansion and/or collapse.

[0007] One known reinforcement mechanism for ductworks is shown in Figure 1 and includes a threaded tie rod 2 oriented between opposite planar sides of a rectangular duct 4. Fixed, inner washers 6 are disposed adjacent the interior side of the opposing duct walls 4, while exterior washers 8 are disposed on the exterior of the duct walls 4 in matching relation to one another. As shown in Figure 1, a threaded nut 10 is screwed down against each of the exterior washers 8 to secure the reinforcing tie rod in position.

[0008] There are several variations of the reinforcing mechanism shown in Figure 1 and these variations may also include rubber o-rings or other elastic sealing devices disposed between the washers and the duct walls. Moreover, it is also known to replace the fixed, inner washers 6 with threaded nuts or lock nuts which may then be tightened in association with the tightening of the exterior threaded nuts 10 to provide the necessary rigidity to the reinforcing mechanism.

[0009] Figure 2 illustrates a cross-sectional view of another known reinforcing mechanism which is comprised of a metallic tube 10 and an insert 12. After the insert 12 has been disposed within the tube 10, the tube 10 is crimped so as to deform in a radially inward direction. The crimped section of the tube 10 becomes locked within an annular groove 14 which has been inscribed about the periphery of the insert 12, thus locking the insert 12 within the tube 10. A threaded bolt 14 extends from the insert 12 and would extend beyond the exterior of a duct wall to be secured thereto via a threaded nut, or the like. The insert 10 may also include an inner cavity to accommodate an unillustrated biasing member, such as a spring, wherein the spring would outwardly bias the

bolt 16 for greater flexibility. The insert 12 may be made from a metallic material or from a plastic or polymer material.

[0010] While these known reinforcing mechanisms are successful to a degree, they suffer from several logistical problems. The threaded tie rod 2 shown in Figure 1 is expensive to produce and deploy in a duct of any length. Similarly, the insert 12 shown in Figure 2 is also prohibitively expensive.

[0011] With the forgoing problems and concerns in mind, it is the general object of the present invention to provide a duct reinforcing rod which overcomes the above-described drawbacks while maximizing effectiveness and flexibility in the assembling process.

### **SUMMARY OF THE INVENTION**

[0012] It is an object of the present invention to provide a reinforcing rod for ducts.

[0013] It is another object of the present invention to provide a reinforcing rod for ducts which do not utilize expensive constituent elements.

[0014] It is another object of the present invention to provide a reinforcing rod for ducts which utilize commercially available components.

[0015] It is another object of the present invention to provide a reinforcing rod for ducts which utilizes a pair of crimps to secure a threaded bolt or nut against longitudinal movement therein.

[0016] It is another object of the present invention to provide a reinforcing rod for ducts which will significantly reduce the overall expense of outfitting ductwork with such reinforcing rods.

[0017] It is another object of the present invention to provide a reinforcing rod for ducts is both quick to manufacture, as well as being reliable in use.

[0018] It is another object of the present invention to provide a fabrication apparatus to fabricate the reinforcing rod.

[0019] These and other objectives of the present invention, and their preferred embodiments, shall become clear by consideration of the specification, claims and drawings taken as a whole.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0020] Figure 1 illustrates one known reinforcement mechanism for ductworks.

[0021] Figure 2 is a cross-sectional view of another known reinforcement mechanism for ductworks.

[0022] Figure 3 is a cross-sectional view of a duct reinforcing rod utilizing a bolt element, according to one embodiment of the present invention

[0023] Figure 4 is a cross-sectional view of the duct reinforcing rod shown in Figure 3 after a crimping operation has been accomplished.

[0024] Figure 5 is a cross-sectional view of the duct reinforcing rod utilizing a nut element after a crimping operation has been accomplished, according to another embodiment of the present invention.

[0025] Figure 6 illustrates the reinforcing rod of Figures 3 and 4 as it is employed in association with a duct wall, according to one embodiment of the present invention.

[0026] Figure 7 illustrates the reinforcing rod of Figure 5 as it is employed in association with a duct wall, according to another embodiment of the present invention.

[0027] Figure 8 illustrates a partial, cross-sectional side, planar view of a vertical fabrication apparatus, according to one embodiment of the present invention.

[0028] Figure 9 illustrates a top, planar view of work surface of the vertical fabrication apparatus shown in Figure 8.

[0029] Figure 10 is a partial cross-sectional view of the tubing of the reinforcing rod after it has been loaded into the vertical fabrication apparatus shown in Figure 8.

[0030] Figure 11 is a partial cross-sectional view of the tubing of the reinforcing rod after it has been pushed down upon a bolt arrested in the vertical fabrication apparatus of Figure 8.

[0031] Figure 12 illustrates the closed position of a pair of matching crimper slide blocks shown in Figure 8.

[0032] Figure 13 illustrates a partial cross-sectional view of a horizontal fabrication apparatus, according to another embodiment of the present invention.

[0033] Figure 14 illustrates a partial cross-sectional elevational view of a clamping station.

[0034] Figure 15 illustrates partial cross-sectional elevational view of a crimping station.

[0035] Figure 16 illustrates a side elevation of the horizontal fabrication apparatus of Figure 13.

[0036] Figure 17 illustrates a front elevation of the horizontal fabrication apparatus of Figure 13.

[0037] Figure 18 illustrates the two separate feeding tracks used to supply the insertion elements for the horizontal fabrication apparatus of Figure 13.

### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

[0038] Figure 3 is a cross-sectional view of a duct reinforcing rod **100**, according to one embodiment of the present invention. As depicted in Figure 3, the reinforcing rod **100** includes a metal tubing **102** and a standard bolt, or jam nut, **104**. As illustrated in Figure 3, the tubing **102** and the bolt **104** are sized so that the head **106** of the bolt **104** enjoys a tight fitting relationship with the inner diameter of the tubing **102** when the tubing **102** is pressed over the head **106** in the general direction of arrow A, as will be described in more detail later.

[0039] The tubing **102** is envisioned to be a common, commercially available metallic conduit, such as is utilized in electrical wiring, however the present invention is not limited in this regard as the tubing **102** may alternatively be formed from any elongated, rigid tubing without departing from the broader aspects of the present invention. Likewise, the bolt **104** is envisioned to be a common, commercially available metallic bolt, which itself may be formed from zinc, stainless steel or the like without departing from the broader aspects of the present invention. The utilization of a standard, commercially available threaded nut, in place of the threaded bolt **104** shown in Figures 3 and 4, is also contemplated by the present invention and will be described in more detail later in conjunction with Figure 5.

[0040] It is therefore an important aspect of the present invention that the reinforcing rod **100** is constructed utilizing common, commercially available 'stock' components. By utilizing such components, the present invention significantly reduces the overall cost of manufacturing the reinforcing rod **100**, as compared to prior art devices. Further, and as generally discussed previously, a typical duct system will employ a large number of periodically spaced reinforcing rods, therefore the aggregate savings realized by employing a reinforcing rod according to the present invention is oftentimes quite large.

[0041] Figure 4 illustrates the reinforcing rod **100** after the tubing **102** has been pressed over the head **106** of the bolt **104**. As depicted in Figure 4, the tubing

**102** is pressed over the head **104** so as to extend beyond the head **104** a predetermined amount. Indeed, it will be readily appreciated that the length of the threaded section **108** of the bolt **104** which extends beyond the tubing **104** may be varied in accordance with the specific design characteristics of the ductwork and the relative length of the bolt **104** utilized.

[0042] The reinforcing rod **100** shown in Figure 4 is crimped in a radially inward direction so as to capture the head **104** therebetween. In contrast to prior art devices, the present invention employs both first and second crimps, **110** and **112** respectively, disposed above and below the head **106** to ensure against longitudinal movement of the bolt **104** within the tubing **102**.

[0043] Figure 5 illustrates a reinforcing rod **150** utilizing a threaded nut **152** in place of the bolt **104** shown in Figures 3 and 4, according to another embodiment of the present invention. As depicted in Figure 5, the tubing **102** is pressed over the nut **152** and the tubing **104** is then is crimped in a radially inward direction so as to capture the nut **152** therebetween. As discussed in conjunction with Figures 3 and 4, the present invention employs both first and second crimps, **110** and **112** respectively, disposed above and below the nut **152** to ensure against longitudinal movement of the nut **152** within the tubing **102**.

[0044] It is therefore another important aspect of the present invention that the reinforcing rod **100/150** need not employ an inscribed, annual groove, or the like, in order to securely fix the bolt **104** or, alternatively, the nut **152**, from longitudinal movement within the tubing **102**.

[0045] Figure 6 illustrates the reinforcing rod **100** as it is employed in association with a duct wall **154**. As shown in Figure 6, the reinforcing rod **100** is secured against the duct wall **154** via the application of a nut **156** having matching threads with the bolt **106** fixed within the tubing **102**. Alternatively, Figure 7 illustrates the reinforcing rod **150** as it is secured against the duct wall **154** via the application of a bolt **158** having matching threads with the nut **152** fixed within the tubing **102**. Although not illustrated, the present invention also



contemplates the use of rubber o-rings, washers, or the like, in conjunction with matching, threaded companions to the bolt **104** or the nut **152** to secure the reinforcing rod **100/150** to the planar sides of a duct. As will be appreciated, the rubber o-rings, washers, or the like may be utilized adjacent to the duct wall **154** in order to substantially attenuate or eliminate vibration of the duct wall **154** during air movement through the ductwork.

[0046] Reference will now be made to Figures 8-12 in order to more completely describe a fabrication apparatus of the reinforcing rod **100**, according to one embodiment of the present invention. Figure 8 illustrates a partial, cross-sectional side, planar view of a vertical fabrication apparatus **200**, according to one embodiment of the present invention. As shown in Figure 2, the vertical fabrication apparatus **200** generally includes a housing **202**, a work surface **204** and a rack and pinion mechanism **206**. The rack and pinion mechanism **206** further includes a tube pushing cylinder **208** which, when selectively actuated, serves to move the rack **210** in a vertical direction, thereby causing the pinions **212** to rotate accordingly. The movement of the pinions **212** cause the tube **102** to be pushed down over the head **106** of the bolt **102**, as will be described in more detail later.

[0047] A planar top view of the work surface **204** is depicted in Figure 9 and illustrates an arresting depression **214** in which the bolt **104** is mounted to await the movement of the tubing **102** thereon. A matching pair of crimper slide blocks **216** are also shown in Figure 9 and are selectively slidable towards one another in order to accomplish the formation of the crimps **110** and **112**, shown in Figure 4.

[0048] In operation, the tubing **102** is mounted within the rack and pinion mechanism **206**, as illustrated in Figure 10. As further illustrated in Figure 10, the bolt **104** is mounted in the arresting depression **214** directly under the loaded tubing **102**. A pair of matching tube pushers **218** are disposed on either side of the loaded tubing **102** and operate under the biasing of the pinions **212** as a result of the actuation of the tube pushing cylinder **208**. The tube pushers **218**

are designed to force the tubing **102** in a downward, substantially vertical motion and over the head **106** of the bolt **104**. Figure 11 illustrates the position of the tube pushers **218** after the tubing **102** has been pushed over the head **106** of the bolt **104**.

[0049] Once the tubing has been pushed over the head **106** of the bolt **104**, the pair of crimper slide blocks **216** are actuated and are brought to bear upon the exterior surface of the tubing **102**, as illustrated in Figure 12. As the crimper slide blocks **216** impinge upon the exterior surface of the tubing **102**, a pair of angled crimpers **220**, shown in Figure 9, create the crimps **110** and **112** in the tubing **102**. Thus, the head **106** of the bolt **104** is securely fixed between the crimps **110** and **112**. At this juncture, the tube pushing cylinder **208** is selectively caused to reverse direction and the reinforcing rod **100** is lifted away from the work surface **204** to be subsequently removed. It will be readily appreciated that both ends of the tubing **102** will be deformed to fix a bolt in either end thereof.

[0050] The vertical fabrication apparatus **200** may be electrically, pneumatically or hydraulically operated, or a combination thereof. In the preferred embodiment of the present invention, the operation of the vertical fabrication apparatus **200** is pneumatically actuated.

[0051] While Figures 8-12 discuss the vertical fabrication apparatus **200**, the present invention also contemplates orienting the operation of the fabrication apparatus in the horizontal plane. In this regard, Figure 13 illustrates a partial cross-sectional view of a horizontal fabrication apparatus **300**.

[0052] As shown in Figure 13, the horizontal fabrication apparatus **300** includes a support base **302**, a clamping station **304**, a crimping station **306** and an insertion device **308**. The clamping station **304** and the crimping station **306** each extend across the planar work surface **310** of the horizontal fabrication apparatus **300**, substantially perpendicular to the insertion axis X of the horizontal fabrication apparatus **300**.

[0053] The support base **302** is preferably a block of metal having a plurality of half-cylindrical depressions, **312**, **314** and **316**, formed on the upper side thereof. The depressions are sized to accommodate a conduit of differing diameters and is selectively translatable in the lateral direction, that is, in a direction substantially perpendicular to the insertion axis  $\underline{X}$ , so as to selectively position one of the depressions opposite the tooling opening or aperture of the clamping station **304**.

[0054] Figures 14 and 15 illustrate partial cross-sectional elevational views of the clamping station **304** and the crimping station **306**, respectively. As shown in Figure 14, the clamping station includes a pair of pneumatically actuated clamping arms **318** disposed about the tooling aperture **320**. It is the function of the clamping station **304** to securely hold the conduit **322** (seen in Figure 13) in position, thereby preventing axial or transverse movement of the conduit **322** during the insertion and crimping process, to be discussed in more detail later.

[0055] The arms **318** of the clamping station **304** define an inner, substantially circular opening which act as the tooling aperture **320**. As will be appreciated, the arms **318** may be interchanged so as to provide a tooling aperture of appropriate diameter to match the diameter of the particular conduit being utilized. Moreover, the shape of the inner, circular opening of the arms **318** are meant to arrest, as opposed to deform, the conduit **322**.

[0056] Aligned with the clamping station **304**, the crimping station **306** of Figure 15 includes a pair of pneumatically actuated crimping arms **324** disposed about the tooling aperture **320**. It is the function of the crimping station **306** to produce the crimps, **110** and **112**, that hold the bolt or nut within the conduit **322**, as discussed previously in conjunction with Figures 4 and 5. Indeed, in order to form both sets of crimps, **110** and **112**, in a single operation, the crimping station **306** is preferably provided with two pairs of crimping arms **324**, disposed one behind the other as viewed in Figure 15.

[0057] The arms 324 of the crimping station 306 define inwardly protruding, lateral impact edges 326 which are co-axially aligned with the tooling aperture 320. The inwardly protruding, lateral impact edges 326 serve to impact and deform the conduit 322, thereby producing the crimps 110 and 112 when the arms 324 move towards one another. As will be appreciated, the arms 324 may be interchanged so as to accommodate the diameter of the particular conduit being utilized. Moreover, the arms 324 may also be interchanged, as necessary, to address wear of the inwardly protruding, lateral impact edges 326.

[0058] As best seen in Figures 14 and 15, the clamping station 304 and the crimping station 306 each include matching pairs of stop adjustment bolts 321. The stop adjustment bolts 321 are utilized so as to adjust the amount by which the clamping arms 318 and the crimping arms 324 travel towards one another, and may thereby adjust the fixing pressure of the clamping arms 318 and the impact pressure of the crimping arms 324.

[0059] Taking Figures 13-15 in combination, the conduit 322 is first situated within one of the depressions, 312, 314 and 316, the appropriate one of which has previously been oriented co-axially with the tooling aperture 320. The conduit 322 is then inserted through the tooling aperture 320 of both the clamping station 304 and the crimping station 306 until its distal end is properly located by a block 328, seen in Figure 13. The clamping station 304 is then actuated to cause the arms 318 to move against and fix the conduit 322 during the insertion of the bolt 108 or nut 152 into the conduit 322, and the subsequent crimping action.

[0060] Returning to Figure 13, the insertion device 308 includes a nut insertion punch 330 and a bolt insertion punch 332. The nut insertion punch 330 and the bolt insertion punch 332 are selectively actuatable by a pneumatically operated solenoid 336. The solenoid 336 is itself may be selectively translatable in a direction substantially perpendicular to the insertion axis X so as to selectively position the operable end of the solenoid 336 opposite either the nut insertion punch 330 or the bolt insertion punch 332. In a preferred embodiment of the

present invention, however, the solenoid 336 is maintained in a stationary position, while the nut insertion punch 330 and the bolt insertion punch 332 are selectively translatable for actuation by the solenoid 336.

[0061] One a bolt 108 or nut 152 has been properly loaded in opposition to an impact end 340 of the nut insertion punch 330 or the bolt insertion punch 332, as will be discussed in greater detail later, actuation of the horizontal fabrication apparatus 300 will selectively cause the solenoid 336 to push against the nut insertion punch 330, or the bolt insertion punch 332, and the integral biasing springs 334, thereby urging the bolt 108 or nut 152 into the secured conduit 332 in the direction of insertion axis X. As will be appreciated, the solenoid 336 serves to urge the bolt 108, or nut 152, into the conduit 322 by an amount which properly positions the bolt 108, or nut 152, to accept crimping on either side thereof, as illustrated in Figures 4 and 5.

[0062] The horizontal fabrication apparatus 300 of the present invention also selectively provides for the automatic feeding of the requisite bolts 108, or nuts 152, via a gravity feed device 342. Figures 16 and 17 show side and frontal elevations of the horizontal fabrication apparatus 300, respectively, as equipped with the gravity feed device 342. As shown in Figures 16 and 17, the gravity feed device 342 includes an elevated hopper 344 having two compartments, 346 and 348, for separately storing the bolts 108 and the nuts 152.

[0063] As best seen in Figure 17, the gravity feed device 342 preferably includes two separate feeding tracks, 350 and 352, which hold a plurality of bolts 108 and nuts 152 therein. Figure 18 illustrates the two separate feeding tracks, 350 and 352, as well as their respective tracks, 354 and 356, and shows how the bolt 108 and the nuts 152 are selectively positioned for insertion by the nut insertion punch 330, or the bolt insertion punch 332.

[0064] It will be readily appreciated that after the conduit 322 has been secured by the clamping station 304, and the bolt 108 or nut 152 has been inserted therein via the gravity feed device 342 and the solenoid 336, the crimping station will

imprint the crimps **110** and **112** to the conduit **322** to securely fix the bolt **108**, or nut **152**, within the conduit **322**. All tooling of the horizontal fabrication apparatus **300** will subsequently retract for easy removal of the conduit **322**, which may then be processed in a similar fashion on its opposing distal end, forming the finished reinforcing rod **100** of the present invention.

[0065] As will be appreciated by consideration of the embodiments illustrated in Figures 1-18, the present invention provides a reinforcing rod for ducts which utilize standardized components to form a rigid and economical stabilizer. Moreover, the formation of a pair of first and second crimps to securely fix a standard bolt there between, including an fabrication apparatus for accomplishing this crimping, provides a heretofore unknown securing configuration which is both quick to manufacture, as well as being reliable in use. By employing the vertical fabrication apparatus **200**, or the horizontal fabrication apparatus **300**, to form the reinforcing rod **100**, the present invention significantly reduces the time, labor and expense of preparing stabilization and reinforcing rods for use in commercial and residential ductwork.

[0066] While the invention has been described with reference to the preferred embodiments, it will be understood by those skilled in the art that various obvious changes may be made, and equivalents may be substituted for elements thereof, without departing from the essential scope of the present invention. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed, but that the invention includes all equivalent embodiments.